PURDUE ROAD SCHOOL

Organizers: Hubo Cai and Dulcy Abraham, Purdue University

Panelists:

Jeff Brechbill, First Group Engineering

John Lendrum, Norwalk Concrete Industries

Tommy Nantung, INDOT

Andrew Pangallo, INDOT

Speakers

- **John Lendrum** – President of Norwalk Concrete Industries, Norwalk Ohio, a regional producer of precast concrete products for DOT, industrial, commercial and infrastructure applications. Mr. Lendrum is a 1980 Graduate of the Krannert School at Purdue, retired Colonel in the United States Army and past Chairman of the National Precast Concrete Association.

- **Jeff Brechbill** – graduated from Valparaiso University in 1996 with a BS in Civil Engineering. Upon graduation, he worked for INDOT Central Office Division of Design until October 1998, when he accepted a position with First Group Engineering as a Roadway Design Engineer. Having now been there for over 25 years, Jeff is currently President and part owner of First Group Engineering.

- **Andrew Pangallo** – 2009 Purdue Grad with 14 years of experience. Current role is the Construction Digital Delivery Lead Engineer responsible for collaborating with civil engineering community including INDOT Central and District Design, Construction, and Operation Offices, Software company/vendors, consultants, and contractors on the implementation of digital delivery for design and construction. He managed the I-69 Finish Line Corridor construction from Martinsville to I-465 and coordinating the construction efforts with the design teams of each segment. Provided support to other current major projects such as Clear Path. Also served as a Field Engineer supporting Greenfield District. Project Engineer on other notable projects: Accelerate 465 and I-465/I-65 South Interchange Modification.

- **Tommy Nantung, Ph.D., PE** – Research Manager for the Indiana Department of Transportation, Division of Research and Development in West Lafayette, Indiana. He represents the Indiana Department of Transportation in AASHTO Special Committee

Outline

- Introduction
- Panelists Presentations
  - Growth of precast concrete systems (PCS)
  - Common types of structures
  - Common challenges
  - Specific perspectives on quality management
  - Stakeholders and involved parties
  - Defects – inspection, identification, and correction
- Q & A

Benefits of Precast Concrete Systems (PCS)

- Minimized traffic disruption
- Shorter project duration
- Increased quality and durability of infrastructures
- Lower project life-cycle costs
- Improved worker and motorist safety

Accelerated bridge construction with precast concrete

[redacted] Tim
e Savings

Limitations of current quality management (QM) practice

- Isolated within each lifecycle stage
- Labor-intensive and sporadic inspections.
  - Possibility of missing quality problems
  - Adverse impacts on subsequent operations

Rebar corrosion caused by low concrete cover [2]

Missing rebars during reinforcement placement [3]

Chipping of concrete segments missed to identify at plant [4]

Examples of quality concerns

[redacted]

ontrol in Precast Concrete Constru[illegible]on

Overarching goal

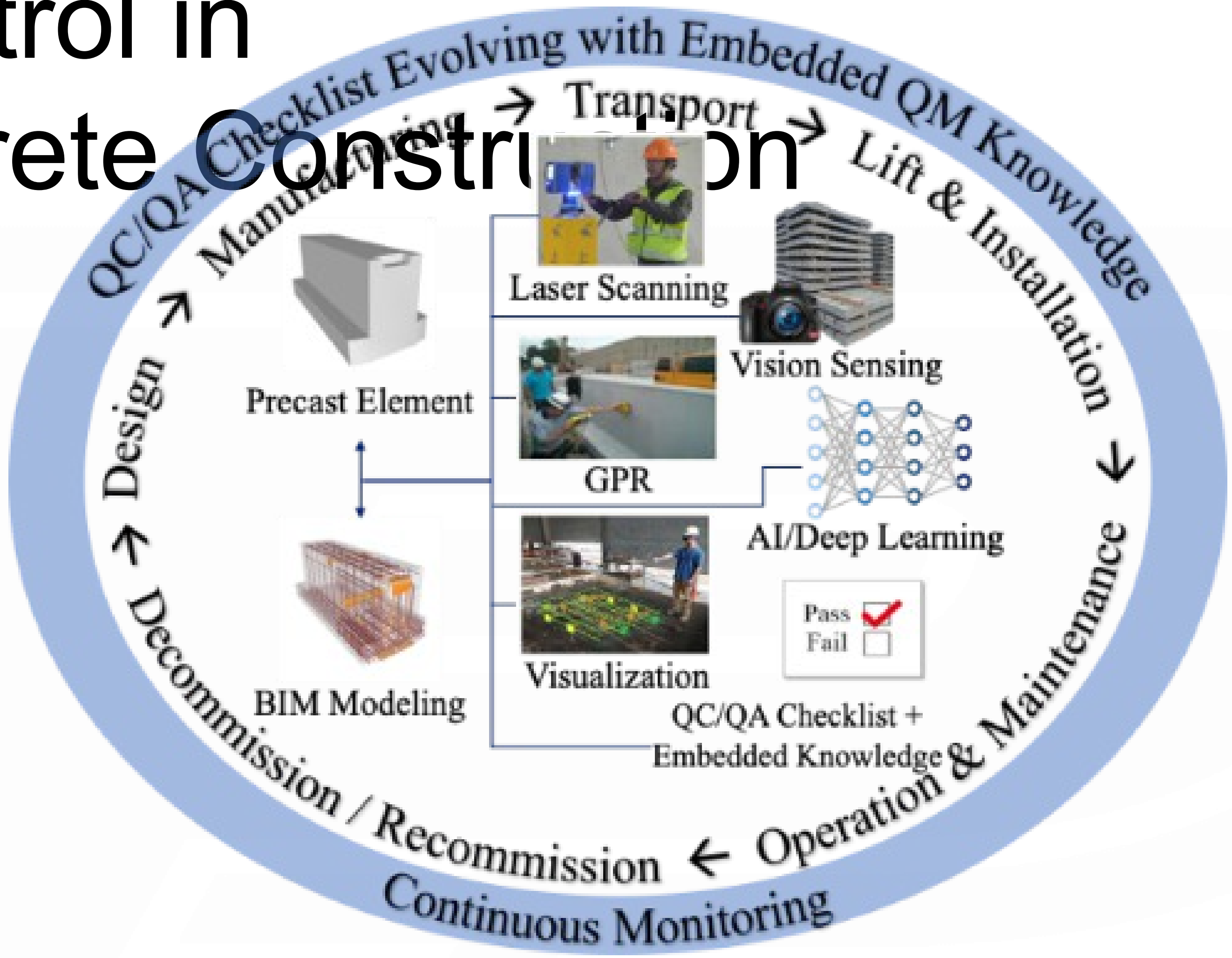
To *develop*, *validate* and *test* a holistic quality management framework/model for precast construction of transportation infrastructure

Objectives

1. Designing a system-level framework for lifecycle QM of PCS
2. Exploiting BIM for PCS in the precast-at-plant stage

Project Advisory Committee (PAC)

- INDOT and neighboring DOTs
- Contractors (First Group Engineering)
- Precasters (certified with INDOT)

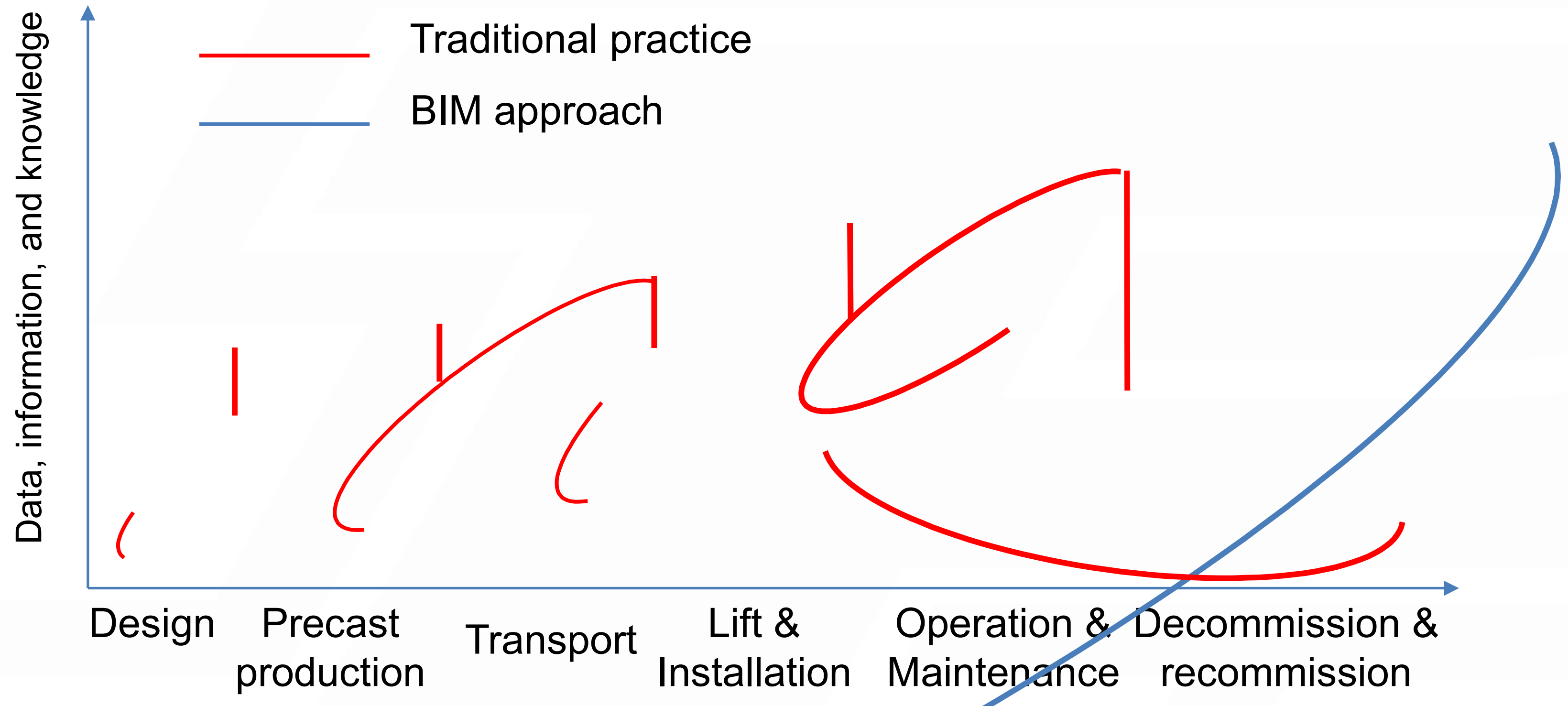


Digital twin for holistic QM in PCS

[redacted] QM

Building Information Modeling (BIM) enables

- Standard storage of data/information
- Seamless exchange of information/knowledge
- Continuous accumulation of information/knowledge

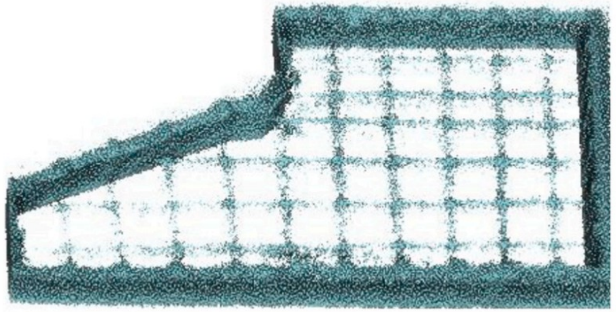


Comparison of data/info./knowledge communication efficiency

[redacted]ologies

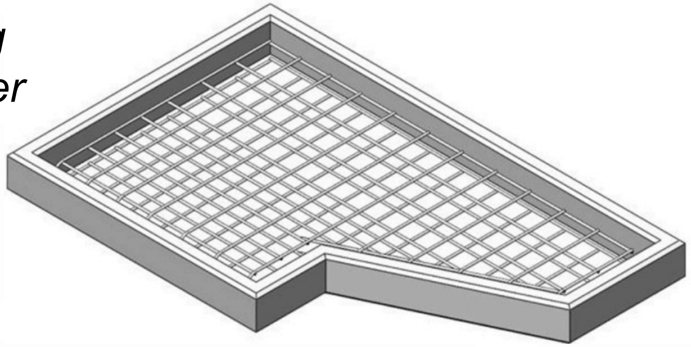
- Automate laborious inspection tasks
- Improve safety
- Enable the “live” **digital twin** (DT)

Laser Scanner

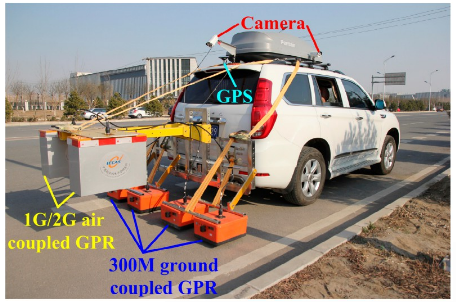


3D Point Cloud

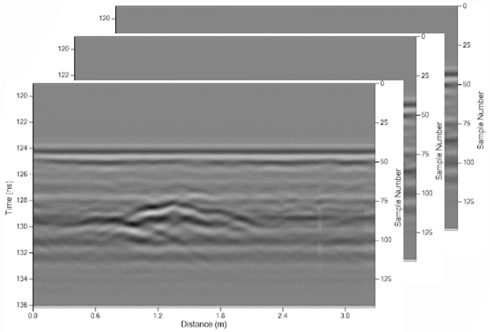
Rebar spacing
Rebar diameter
Slab size
… …



BIM Form Model

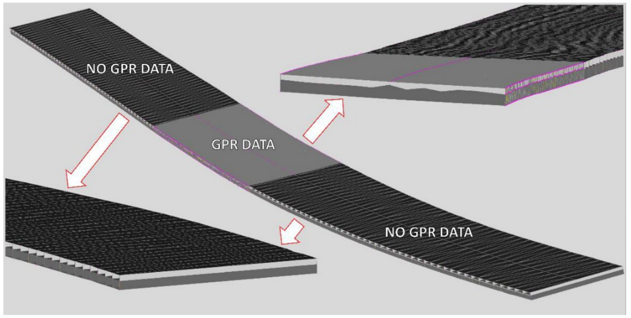


Ground Penetrating Radar (GPR)



Scan Images

Defect size
Defect location
Defect rating
… …



BIM Pavement Model

“Live” digital twin enabled by scan-to-BIM [5, 6, 7]

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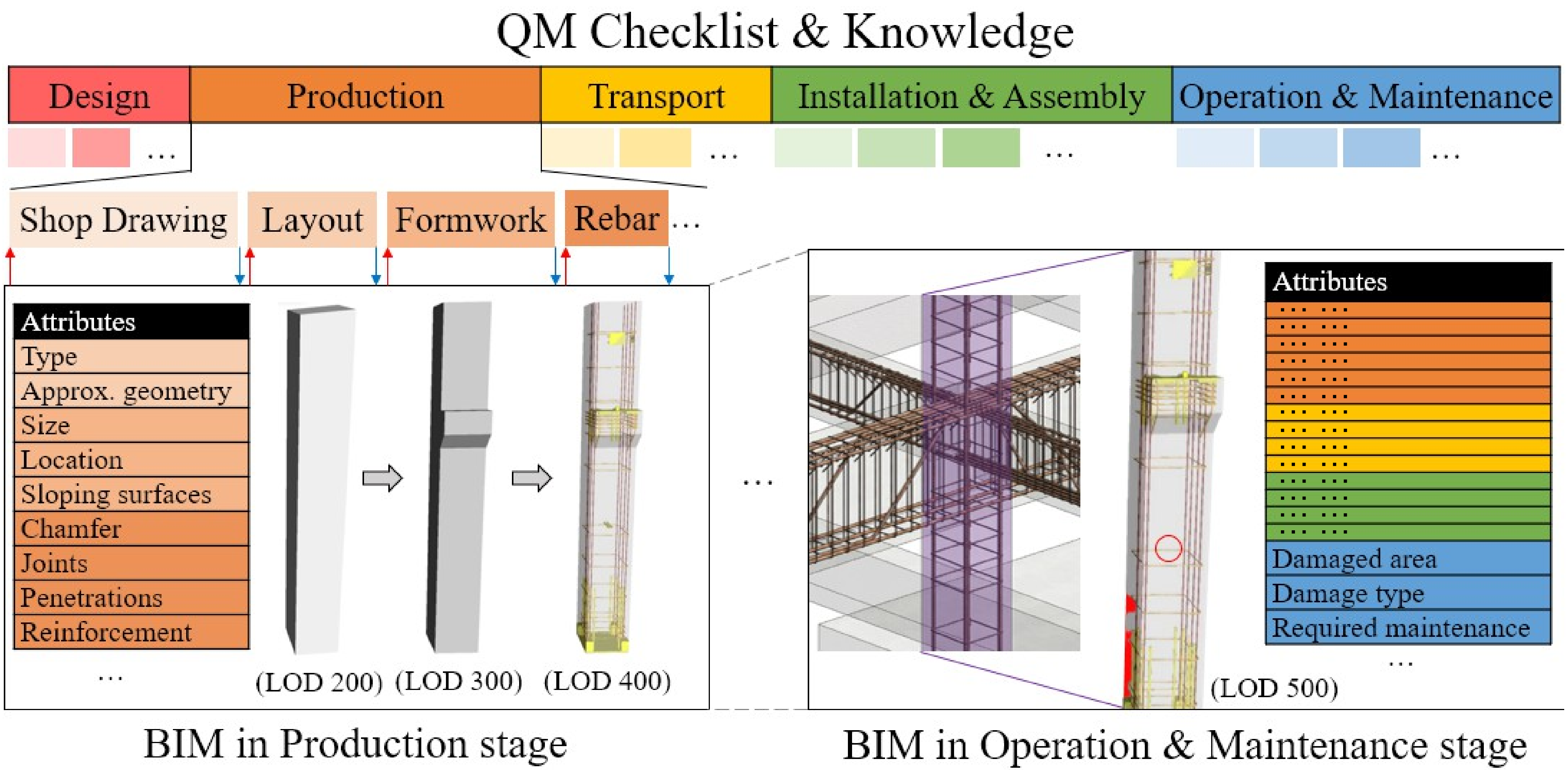

BIM-based dynamic framework for PCS QM

John Lendrum

Norwalk Concrete Industries

CONSTRUCTION ENGINEERING & MANAGEMENT
PURDUE

Laboratory of Computer-Integrated Infrastructure Informatics
PURDUE UNIVERSITY

Growth of Precast in Transportation Infrastructure

- Precast Limits Jobsite Labor Costs and Speeds Erection or Installation
- Limited Only By Site Access, Crane Capacity and Design


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Most Common Types of Structures

- Storm and Sanitary Drainage is the Largest Single Market
- Sound and Retaining Walls of all Types
- Highway Barrier
- Utility Products; Vaults, Pullboxes, Specialty Structures
- Bridge Components

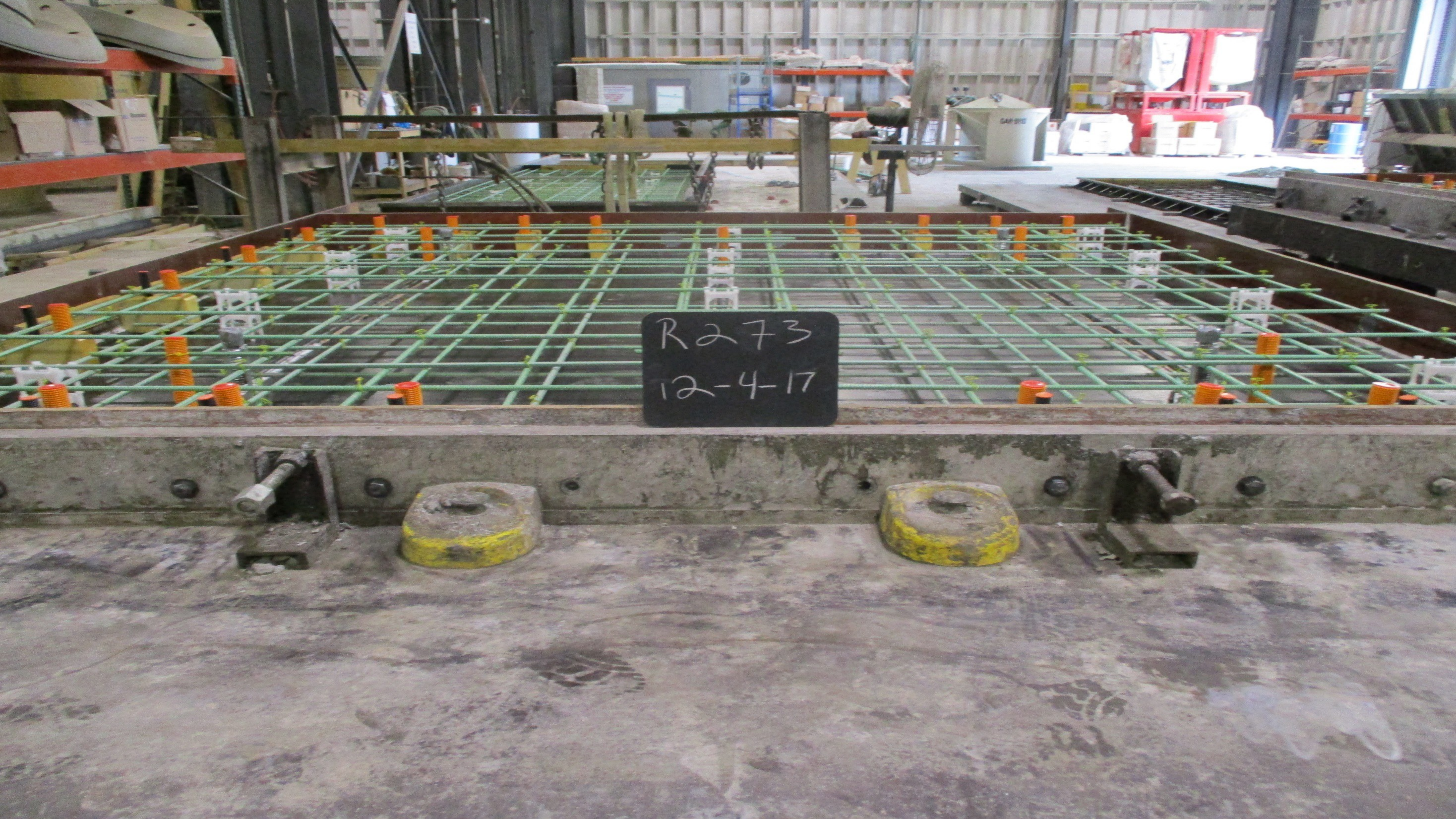

NCI
NPCA

[redacted]

- Recruiting and Retention of Qualified Labor
- Impact of Construction Material Inflation on Multi Year Projects
- Government Regs with Environmental Rules Being Most Challenging


HISTORIC DOWNTOWN
THE
MARKET
MOUNT STERLING
X1785

- PCI and NPCA Plant Certification Programs Improve Precast
- Dedicated Plant QC Personnel and a Controlled Inspection Program
- Mulitple ACI Level I Technicians
- Industry Training Opportunities NPCA Master Precaster Program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CAT
E&B PAVING

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- Customers, Specifiers, and DOT Officials
- Vendor Support with New Technology and Products
- Value of Industry Meetings and Training Attendance
- The Precast Show Indianapolis February 2024
- National Precast Concrete Association   www.precast.org

Defects – Inspection, Identification, and Correction

- Pre Pour, Post pour, and Shipping Inspections
- Written Repair Procedures; Understand What Is a Problem
- Most Damage Occurs In Shipping and Jobsite Handling
- Undersized Lift Equipment; Short Chain Rigging, Travel Distance


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Jeff Brechbill
First Group Engineering

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The First Precast Concrete Pavement in Indiana

Contract R-30397

US 40 – Des. 0013790

City of Richmond, Indiana

INDOT Greenfield District

Letting Date: February 8, 2017

Prime Contractor: Gradex

Precast Concrete Pavement – US 40 Eastbound

(South A Street) from South 3rd Street to South 11th Street and

(South 11thStreet) from South A Street to East Main Street

Growth of Precast in Transportation Infrastructure

Downtown Richmond, Indiana

U.S. 40 Project Limits

Common Challenges

Maintenance of Traffic & Constructability

[redacted]

Maintenance of Traffic & Constructability

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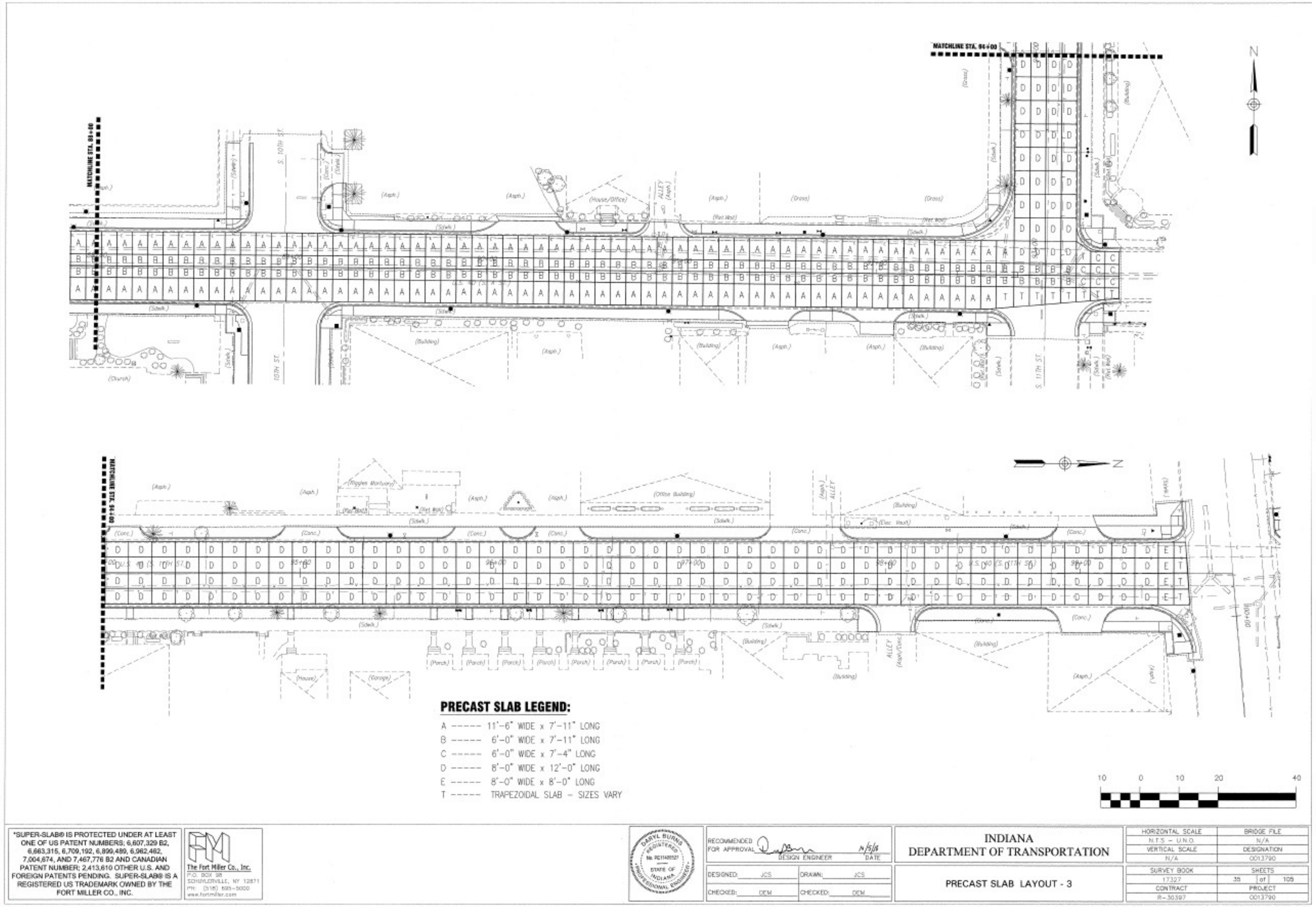
Maintenance of Traffic & Constructability


MATCHLINE STA. 84+00
MATCHLINE STA. 83+00
PRECAST SLAB LEGEND:
A ----- 11'-6" WIDE x 7'-11" LONG
B ----- 6'-0" WIDE x 7'-11" LONG
C ----- 6'-0" WIDE x 7'-4" LONG
D ----- 8'-0" WIDE x 12'-0" LONG
E ----- 8'-0" WIDE x 8'-0" LONG
T ----- TRAPEZOIDAL SLAB - SIZES VARY
INDIANA
DEPARTMENT OF TRANSPORTATION
PRECAST SLAB LAYOUT - 3
The Fort Miller Co., Inc.

Unique Special Provisions: Allowable Tolerances

Produce slabs to the following tolerances:

Material	Proportion
Length	+/- 1/4 inch
Width	+/-1/4 inch
Thickness	+/-1/8 inch
Difference in diagonals	not to exceed 3/16 inch
Edge squareness	1/8 inch in 10 inches in relation to top and bottom surfaces
Delta	+/- 1/8

6. Preparation of Subbase

Subbase for PCCP shall be placed and shaped to the required grade and section in accordance with 302 modified by the specification included in this contract and that the top of the aggregate course shall be checked transversely and all deviations in excess of 1/4 in. shall be corrected.

7. Grading, supergrading, of Bedding Material

The supergraded bedding material surface is the grade control for the new slabs. Accomplish supergrading of the bedding material using a laser or otherwise mechanically-controlled screeding device. Ensure the screeding device is capable of supergrading fully compacted bedding material in accordance with the Plans, Super-Slab® System Standard Fabrication and Installation Drawings and this Specification. Ensure the screeding device is fully adjustable to achieve the required cross slope and profile of each pavement slab to the required tolerances. Other grading devices and methods may be used, provided the Contractor demonstrates they are capable of grading fully compacted bedding material to the required tolerances. Hand grading under string lines is not allowed.

e. **Surface Spalls**—Surface spalls less than 1/4 in. deep may not require repair, particularly because the pavement surface will be diamond ground. If the spalled area is larger than four in. in diameter, repair shall be considered. Spalls greater than 1/4 in. deep shall be repaired.

f. **Panel Edge and Corner Spalls**—Spalling of panel edges and corners that abut adjacent pavement or other PPCP panels shall be repaired so that a durable joint is achieved. Use partial depth repair techniques in accordance with 506.10(a) to repair the spalled areas. Spalling of the panel edges at an exterior edge or corner such as in the shoulder of the panel may not need to be repaired, at the discretion of the agency.

g. **Blockouts, Lifting Anchors, and Grout Port Fill Material**—If spalling occurs around blockouts or the lifting anchor recesses during panel installation or post-tensioning, the areas shall be repaired. Partial depth patching techniques in accordance with 506.07(a) and 506.10(a) can be used to remove the spalled concrete and the repair can be made when the blockout or lifting anchor recess is initially filled.

e. **Full-Depth Cracks**—Full-depth cracks are oriented transversely or longitudinally. Full-depth cracks shall be evaluated to determine the likely cause, as they may indicate a structural flaw in the pavement and can have a significant effect on pavement performance. If it is determined that a more serious structural flaw is not evident, epoxy injection can be used to repair the crack with the understanding that reoccurrence of the crack or additional cracking after repair may be cause for a more rigorous repair, such as partial-depth patching.

f. **Cracks at Filled Blockouts and Lifting Anchors**—Cracks around the perimeter of a blockout or lifting anchor occur if the face of the blockout or lifting anchor recess is not properly wetted or painted with epoxy bonder prior to placing the fill material, or if the fill is not properly cured, resulting in shrinkage. The guidelines presented above for surface cracks shall be used to determine whether treatment is needed based on crack width and exposure conditions.

Andrew Pangallo
INDOT

Most Common Types of Structures

Common Challenges

nd C

INDOT
Digital Inspection System

Use this form to retrieve check items for the selected pay item

Select Pay Item

715-08162

Applicable Check Items

PayItemID	CheckIten	CheckQuestion	InspectionFrequenc	tblCheckItem.Typ	Responsibility
715-08162	715-001	Type 1 pipe shall be used for culverts under mainline pavement and public road approaches and shall be in accordance with the following:Clay Pipe, Extra Strength 907.08Corrugated		Check	
715-08162	715-018	Unless otherwise directed, the trench cross sectional dimensions and the trench bottom shall be as shown on the plans. Recesses shall be cut to receive any projecting hubs or bells.		Information	
715-08162	715-019	If rock or boulder formations are encountered at or above the proposed trench bottom elevation, the trench shall be excavated at least 8 in. below the proposed grade, backfilled with structure backfill, and compacted in		Information	
715-08162	715-020	In case a firm foundation is not encountered at the required grade, the unstable material shall be removed to such depth that when replaced with suitable material, usually B borrow, compacted, and properly shaped, it will		Information	
715-08162	715-021	All trenches shall be kept free from water until any joint filling material has hardened sufficiently not to be harmed.		Check	
715-08162	715-022	Each section of pipe shall have a full firm bearing throughout its length, true to the line and grade given. All pipes which settle or which are not in alignment shall be taken up and re-laid. Pipe shall not be laid on a frozen		Information	
715-08162	715-023	Fully bituminous coated and lined pipe and pipe-arches shall only be placed when the ambient temperature is 35°F or above.		Information	

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Outlet Erosion

Flowline issues

Stakeholders and Involved Parties

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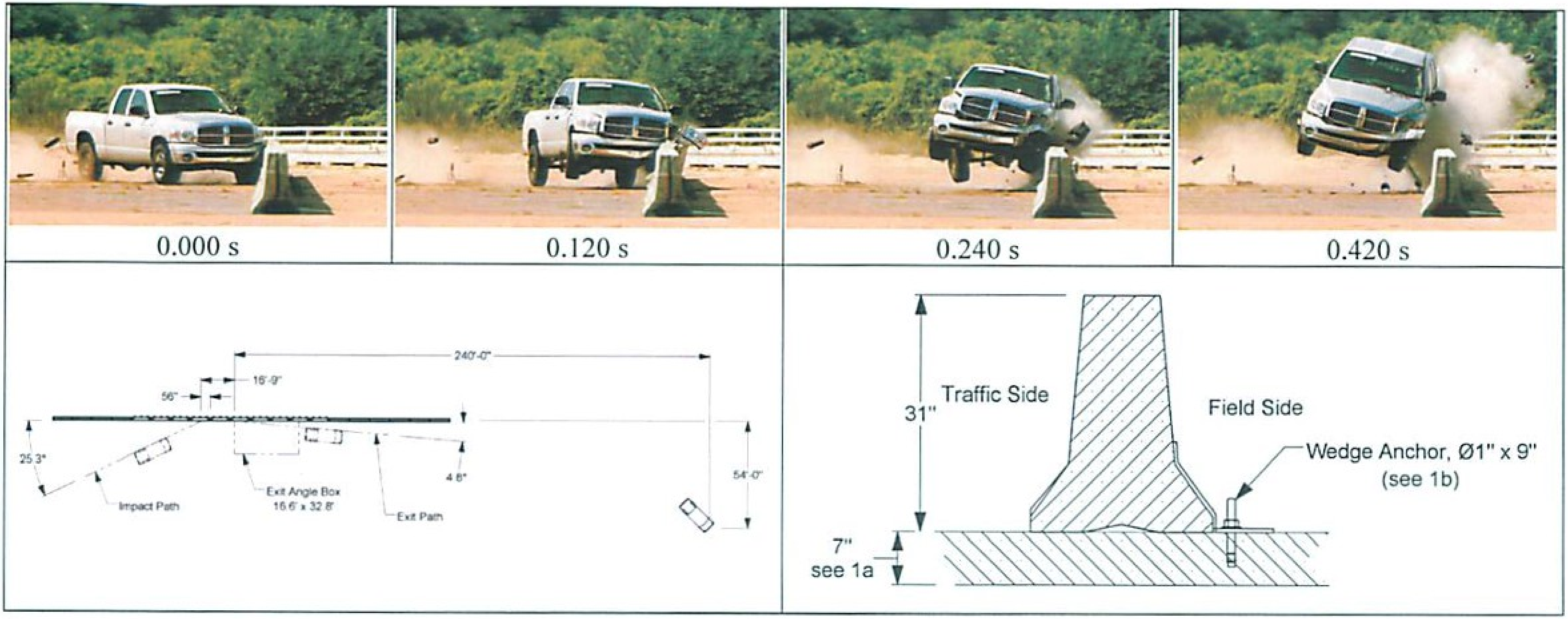

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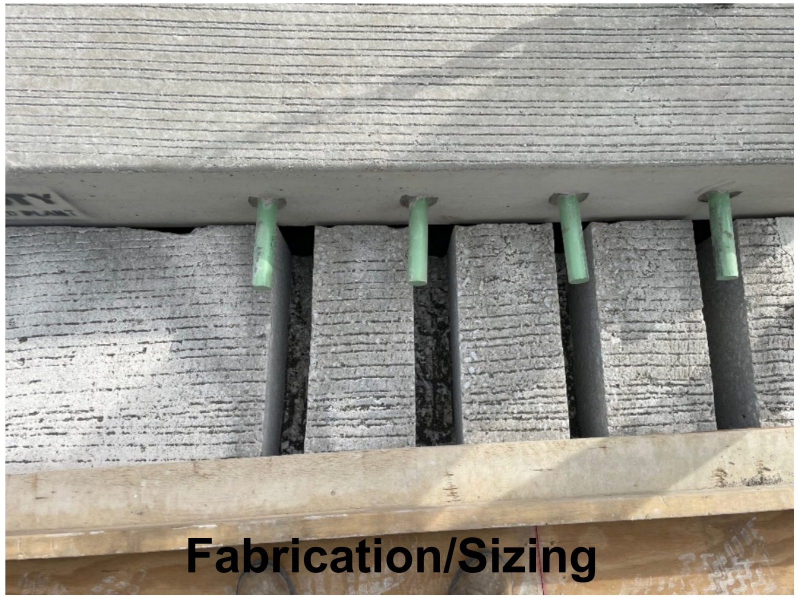
Tommy Nantung PhD PE
INDOT Research and Development Division

Growth of precast applications and typical uses

- Short opening to traffic
  - Concrete pavement renewal fo r short range.
  - Concrete pavement reactive m aintenance (slab replacement).
- Mechanically Stabilized Earth Walls (MSE Walls)
  - Based in INDOT approved syst ems.
- Bridge elements
  - Prestressed beams, based on

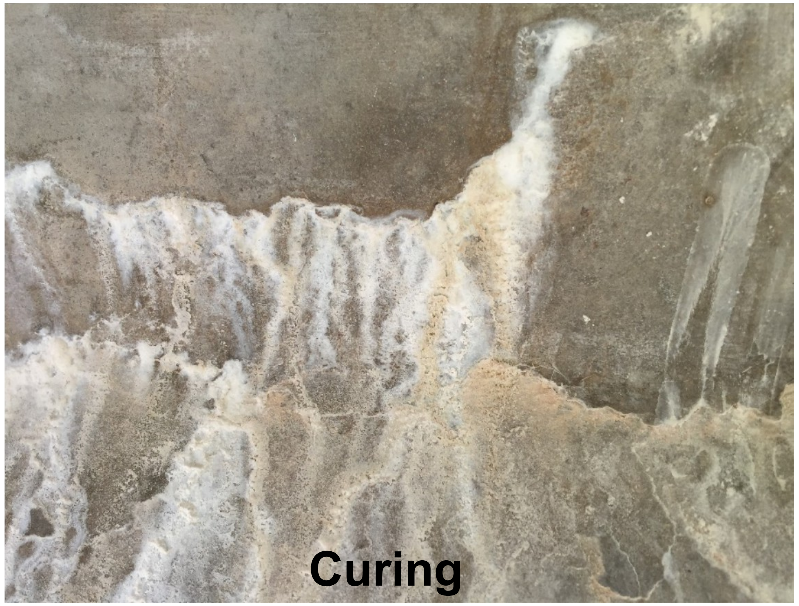
Common Challenges in Precast Elements


Fabrication/Sizing


Curing/FIFO


Shipping/Handling


Curing


Curing

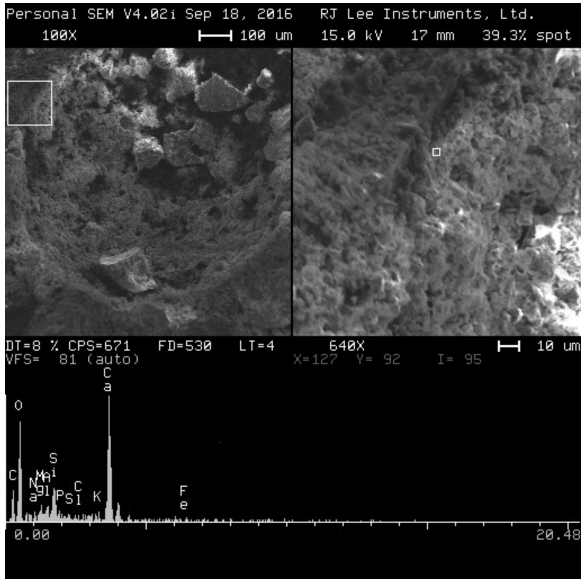

Handling

Perspective of Quality Management

- The quality of the precast con crete element should exist fro m end to end until the precas t element is in service
  - Sizing and meet the tolerances
  - Formwork and structural eleme nts
  - Concrete mixes
  - Placement of concrete and fini shing
  - Curing and keep curing the co

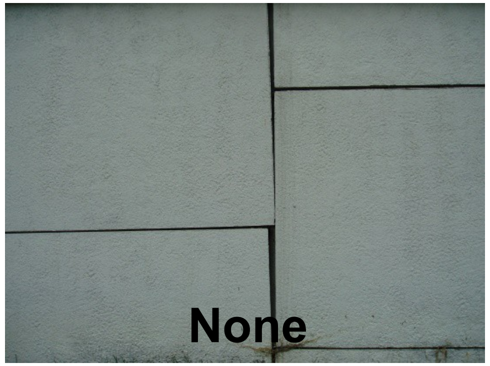
Identifying defect

- Visual inspection is the first to detect defect
- Non-Destructive Testing (NDT) to detect structural defects
  - Pulse velocity
  - Ground Penetrating Radar (GPR)
  - Ultrasonic Tomography
- Lab investigation
  - Optical Microscope



Corrections

- Determined by the inspectors in the fabrication plants
- Corrections at the fabrication plants
  - Cosmetic corrections
  - Other structural/non-structural corrections
- Corrections in the constructio n site
  - Usually “adjustment” that will n ot compromise performance



TRANS-IPIC
TRANSPORTATION INFRASTRUCTURE PRECAST INNOVATION CENTER

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